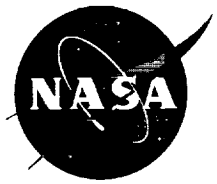
NASA/TM—2000–210130



FY 1999 Scientific and Technical Reports, Articles, Papers, and Presentations

Compiled by
J.E. Turner Waits
Marshall Space Flight Center, Marshall Space Flight Center, Alabama

March 2000

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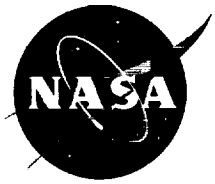

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FOREWORD

In accordance with the NASA Space Act of 1958, the MSFC has provided for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof.

Since July 1, 1960, when the George C. Marshall Space Flight Center was organized, the reporting of scientific and engineering information has been considered a prime responsibility of the Center. Our credo has been that "research and development work is valuable, but only if its results can be communicated and made understandable to others."

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GEORGE C. MARSHALL SPACE FLIGHT CENTER
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FY 1999 SCIENTIFIC AND TECHNICAL REPORTS
ARTICLES, PAPERS, AND PRESENTATIONS

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TM—1998–209004 December 1998

High-Strength Aluminum Casting Alloy for High-Temperature Applications (MSFC Center Director's Discretionary Fund Final Report, Project No. 97–10). J.A. Lee. 19990019483N

A new aluminum-silicon alloy has been successfully developed at Marshall Space Flight Center that has a significant improvement in tensile strength at elevated temperatures (550 to 700 °F). For instance, the new alloy shows an average tensile strength of at least 90 percent higher than the current 390 aluminum piston alloy tested at 500 °F. Compared to conventional aluminum alloys, automotive engines using the new piston alloy will have improved gas mileage, and may produce less air pollution in order to meet the future U.S. automotive legislative requirements for low hydrocarbon emissions. The projected cost for this alloy is <$0.95/lb, and it readily allows the automotive components to be cast at a high production volume with a low, fully accounted cost. It is economically produced by pouring molten metal directly into conventional permanent steel molds or die casting.

TM—1999–209009 January 1999

A TREETOPS Simulation of the STABLE Microgravity Vibration Isolation System. G.S. Nurre, Y.K. Kim,* and M.S. Whorton. Structures and Dynamics Laboratory and *University of Alabama in Huntsville. 19990021252N

As a research facility for microgravity science, the *International Space Station* (*ISS*) will be used for numerous experiments which require a quiescent acceleration environment across a broad spectrum of frequencies. For many microgravity science experiments, the ambient acceleration environment on *ISS* will significantly exceed desirable levels. The ubiquity of acceleration disturbance sources and the difficulty in characterization of these sources precludes source isolation, requiring vibration isolation to attenuate the disturbances to an acceptable level at the experiment. To provide a more quiescent acceleration environment, a vibration isolation system named STABLE (Suppression of Transient Accelerations By LEvitation) was developed. STABLE was the first successful flight test of an active isolation device for microgravity science payloads and was flown on STS–73/USML–2 in October 1995. This report documents the development of the high fidelity, nonlinear, multibody simulation developed using TREETOPS which was used to design the control laws and define the expected performance of the STABLE isolation system.

TM—1999–209039 January 1999

Unlined Reusable Filament Wound Composite Cryogenic Tank Testing. A.W. Murphy, R.E. Lake, and C. Wilkerson. Propulsion Laboratory. 19990019399N

An unlined reusable filament wound composite cryogenic tank was tested at Marshall Space Flight Center using LH_2 cryogen and pressurization to 320 psig. The tank was fabricated by Phillips Laboratory and Wilson Composite Group, Inc., using an EnTec five-axis filament winder and sand mandrels. The material used was 1M7/977–2 (graphic/epoxy).

TM—1999–209091 February 1999

A Photometric Technique for Determining Fluid Concentration Using Consumer-Grade Hardware. F. Leslie and N. Ramachandran.* Space Sciences Laboratory and *Universities Space Research Association. 19990110469N

In support of a separate study to produce an exponential concentration gradient in a magnetic fluid, a noninvasive technique for determining species concentration from off-the-shelf hardware has been developed. The approach uses a backlighted fluid test cell photographed with a commercial digital camcorder. Because the light extinction coefficient is wavelength dependent, tests were conducted to determine the best filter color to use, although some guidance was also provided using an absorption spectrophotometer. With the appropriate filter in place, the attenuation of the light passing through the test cell was captured by the camcorder. The digital image was analyzed for intensity using software from Scion Image Corp. downloaded from the Internet. The analysis provides a two-dimensional array of concentration with an average error of 0.0095 ml/ml. This technique is superior to invasive techniques, which require extraction of a sample that disturbs the concentration distribution in the test cell. Refinements of this technique using a true monochromatic laser light source are also discussed.

TM—1999–209147 February 1999

Measurement of Plastic Stress and Strain for Analytical Method Verification (MSFC Center Director's Discretionary Fund Final Report, Project No. 93–08). J.M. Price, B.E. Steeve, and G.R. Swanson. Structures and Dynamics Laboratory. 19990032090N

The analytical prediction of stress, strain, and fatigue life at locations experiencing local plasticity is full of uncertainties. Much of this uncertainty arises from the material models and their use in the numerical techniques used to solve plasticity problems. Experimental measurements of actual plastic strains would allow the validity of these models and solutions to be tested. This memorandum describes how experimental plastic residual strain measurements were used to verify the results of a thermally induced plastic fatigue failure analysis of a Space Shuttle main engine fuel pump component.

TM—1999–209148 February 1999
NDE Process Development Specification for SRB Composite Nose Cap. M. Suits. Material and Processes Laboratory. 19990028512N

The Shuttle Upgrade program is a continuing improvement process to enable the Space Shuttle to be an effective space transportation vehicle for the next few decades. The Solid Rocket Booster (SRB), as a component of that system, is currently undergoing such an improvement. Advanced materials, such as composites, have given us a chance to improve performance and to reduce weight.

The SRB Composite Nose Cap (CNC) program aims to replace the current aluminum nose cap, which is coated with a Thermal Protection System and poses a possible debris hazard, with a lighter, stronger CNC. For the next 2 years, this program will evaluate the design, material selection, properties, and verification of the CNC. This particular process specification cites the methods and techniques for verifying the integrity of such a nose cap with nondestructive evaluation.

TM—1999–209149 March 1999
FY 1998 Scientific and Technical Reports, Articles, Papers, and Presentations. J.E. Turner Waits, Compiler. Technical Information & Operations Services Office. 19990088072N

This document presents formal NASA technical reports, papers published in technical journals, and presentations by MSFC personnel in FY98. It also includes papers of MSFC contractors.

After being announced in STAR, all of the NASA series reports may be obtained from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

The information in this report may be of value to the scientific and engineering community in determining what information has been published and what is available.

TM—1999–209201 March 1999
A Strategy for Integrating a Large Finite Element Model Using MSC NASTRAN/PATRAN: X–33 Lessons Learned. D.S. McGhee. Structures and Dynamics Laboratory. 19990028385N

The X–33 vehicle is an advanced technology demonstrator sponsored by NASA. For the past 3 years the Structural Dynamics and Loads Branch of NASA's Marshall Space Flight Center has had the task of integrating the X–33 vehicle structural finite element model. In that time, five versions of the integrated vehicle model have been produced and a strategy has evolved that would benefit anyone given the task of integrating structural finite element models that have been generated by various modelers and companies. The strategy that has been presented here consists of six decisions that need to be made: purpose of models, units, common materials list, model numbering, interface control, and archive format. This strategy has been proven and expanded from experience on the X–33 vehicle.

TM—1999–209266 May 1999
Modified Truncated Cone Target Hyperthermal Atomic Oxygen Test Results. J.A. Vaughn, R.R. Kamenetzky, and M.M. Finckenor. Materials and Processes Laboratory. 19990087364N

The modified truncated cone target is a docking target planned for use on the *International Space Station*. The current design consists of aluminum treated with a black dye anodize, then crosshairs are laser etched for a silvery color. Samples of the treated aluminum were exposed to laboratory simulation of atomic oxygen and ultraviolet radiation to determine if significant degradation might occur. Durability was evaluated based on the contrast ratio between the black and silvery white areas of the target. Degradation of optical properties appeared to level off after an initial period of exposure to atomic oxygen. The sample that was not alodined according to MIL–C–5541, type 1A, performed better than alodined samples.

TM—1999–209425 June 1999
Space Sciences Laboratory Publications and Presentations, January 1–December 31, 1998. F.G. Summers, Compiler. Space Sciences Laboratory. 19990062144N

This document lists the significant publications and presentations of the Space Sciences Laboratory during the period January 1–December 31, 1998. Entries in the main part of the document are categorized according to NASA Reports (arranged by report number). Open Literature, and Presentations (arranged alphabetically by title). Most of the articles listed under Open Literature have appeared in refereed professional journals, books, monographs, or conference proceedings. Although many published abstracts are eventually expanded into full papers for publication in scientific and technical journals, they are often sufficiently comprehensive to include the significant results of the research reported. Therefore, published abstracts are listed separately in a subsection under Open Literature. Questions or requests for additional information about the entries in this report should be directed to Gregory S. Wilson (ESOI: 544–7579) or to one of the authors. The organizational code of the cognizant SSL branch or office is given at the end of each entry.

TM—1999–209573 August 1999

International Space Station ECLSS Technical Task Agreement Summary Report. C.D. Ray and B.H. Salyer,* Compilers. Structures and Dynamics Laboratory, and *Ion Corporation. 19990088077N 19990116212N

This Technical Memorandum provides a summary of current work accomplished under Technical Task Agreement (TTA) by the Marshall Space Flight Center (MSFC) regarding the *International Space Station (ISS)* Environmental Control and Life Support System (ECLSS). Current activities include ECLSS component design and development, computer model development, subsystem/integrated system testing, life testing, and general test support provided to the *ISS* program.

Under ECLSS design, MSFC was responsible for the six major ECLSS functions, specifications and standard, component design and development, and was the architectural control agent for the *ISS* ECLSS. MSFC was responsible for ECLSS analytical model development. In-house subsystem and system level analysis and testing were conducted in support of the design process, including testing air revitalization, water reclamation and management hardware, and certain nonregenerative systems.

The activities described herein were approved in task agreements between MSFC and NASA Headquarters Space Station Program Management Office and their prime contractor for the *ISS*, Boeing. These MSFC activities are inline to the designing, development, testing, and flights of ECLSS equipment planned by Boeing. MSFC's unique capabilities for performing integrated systems testing and analyses, and its ability to perform some tasks cheaper and faster to support *ISS* program needs, are the basis for the TTA activities.

TM—1999–209575 September 1999

Comparison of Observed Beta Cloth Interactions With Simulated and Actual Space Environment. R.R. Kamenetzky and M.M. Finckenor. Materials Processes and Manufacturing Department. 19990103958N 19990103942N

A common component of multilayer insulation blankets is beta cloth, a woven fiberglass cloth impregnated with Teflon™. It is planned for extensive use on the *International Space Station*. The Environmental Effects Group of the Marshall Space Flight Center Materials, Processing, and Manufacturing Department has investigated the impact of atomic oxygen (AO) and ultraviolet (UV) radiation on the optical properties of plain and aluminized beta cloth, both in the laboratory and as part of long-duration flight experiments. These investigations indicate that beta cloth is susceptible to darkening in the presence of UV radiation, dependent on the additives used. AO interactions resulted in bleaching of the beta cloth.

TM—1999–209629 May 1999

Mars Global Reference Atmospheric Model (Mars-GRAM) Version 3.8: Users Guide. C.G. Justus* and B.F. James. *Computer Sciences Corporation and Electromagnetics and Systems Analysis and Integration Laboratory. 19990108484N

Mars Global Reference Atmospheric Model (Mars-GRAM) Version 3.8 is presented and its new features are discussed. Mars-GRAM uses new values of planetary reference ellipsoid radii, gravity term, and rotation rate (consistent with current JPL values) and includes centrifugal effects on gravity. The model now uses NASA Ames Global Circulation Model low resolution topography. Curvature corrections are applied to winds and limits based on speed of sound are applied. Altitude of the F1 ionization peak and density scale height, including effects of change of molecular weight with altitude are computed. A check is performed to disallow temperatures below CO_2 sublimation. This memorandum includes instructions on obtaining Mars-GRAM source code and data files and running the program. Sample input and output are provided. An example of

incorporating Mars-GRAM as an atmospheric subroutine in a trajectory code is also given.

TM—1999–209630 May 1999
The NASA/MSFC Global Reference Atmospheric Model—1999 Version (GRAM-99). C.G. Justus* and D.L. Johnson. *Computer Sciences Corporation and Engineering Systems Department.
19990107329N

The latest version of Global Reference Atmospheric Model (GRAM–99) is presented and discussed. GRAM–99 uses either (binary) Global Upper Air Climatic Atlas (GUACA) or (ASCII) Global Gridded Upper Air Statistics (GGUAS) CD-ROM data sets, for 0–27 km altitudes. As with earlier versions, GRAM–99 provides complete geographical and altitude coverage for each month of the year. GRAM–99 uses a specially-developed data set, based on Middle Atmosphere Program (MAP) data, for 20–120 km altitudes, and NASA's 1999 version Marshall Engineering Thermosphere (MET–99) model for heights above 90 km. Fairing techniques assure smooth transition in overlap height ranges (20–27 km and 90-120 km). GRAM–99 includes water vapor and 11 other atmospheric constituents (O_3, N_2O, CO, CH_4, CO_2, N_2, O_2, O, A, He, and H). A variable-scale perturbation model provides both large-scale (wave) and small-scale (stochastic) deviations from mean values for thermodynamic variables and horizontal and vertical wind components. The small-scale perturbation model includes improvements in representing intermittency ("patchiness"). A major new feature is an option to substitute Range Reference Atmospheric (RRA) data for conventional GRAM climatology when a trajectory passes sufficiently near any RRA site. A complete user's guide for running the program, plus sample input and output, is provided. An example is provided for how to incorporate GRAM–99 as subroutines in other programs (e.g., trajectory codes).

TM—1999–209631 September 1999
Deflections of a Uniformly Loaded Circular Plate With Multiple Support Points. L.D. Craig and J.A.M. Boulet*. Structures, Mechanics, and Thermal Department and *University of Tennessee.
19990107327N

This technical memorandum describes a method for determining the transverse deflections of a uniformly loaded, thin circular plate of constant thickness supported by single or multiple rings of equally spaced discreet points. The rotations are assumed free at each point. This could have application in the design of telescope mirror supports that must minimize structural gravitational deformations. It could also be of general use to the structural analyst.

TM—1999–209734 May 1999
Lightning Protection Guidelines for Aerospace Vehicles. C.C. Goodloe. System Analysis and Integration Laboratory.

This technical memorandum provides lightning protection engineering guidelines and technical procedures used by the George C. Marshall Space Flight Center (MSFC) Electromagnetics and Aerospace Environments Branch for aerospace vehicles. The overviews illustrate the technical support available to project managers, chief engineers, and design engineers to ensure that aerospace vehicles managed by MSFC are adequately protected from direct and indirect effects of lightning. Generic descriptions of the lightning environment and vehicle protection technical processes are presented. More specific aerospace vehicle requirements for lightning protection design, performance, and interface characteristics are available upon request to the MSFC Electromagnetics and Aerospace Environments Branch, mail code EL23.

TM-1999-209735 September 1999
Static Strength Characteristics of Mechanically Fastened Composite Joints (MSFC Center Director's Discretionary Fund Final Report, Project No. 95–07). D.E. Fox and K.W. Swaim. Structures, Mechanics, and Thermal Department.
19990111740N

The analysis of mechanically fastened composite joints presents a great challenge to structural analysts because of the large number of parameters that influence strength. These parameters include edge distance, width, bolt diameter, laminate thickness, ply orientation, and bolt torque. The research presented in this report investigates the influence of some of these parameters through testing and analysis. A methodology is presented for estimating the strength of the bolthole based on classical lamination theory using the Tsai-Hill failure criteria and typical bolthole bearing analytical methods.

TP—1998–209003 December 1998

Deciphering the Long-Term Trend of Atlantic Basin Intense Hurricanes: More Active Versus Less Active During the Present Epoch. Robert M. Wilson. Space Sciences Laboratory. 19990021448N

During the interval of 1944–1997, 120 intense hurricanes (i.e., those of category 3 or higher on the Saffir-Simpson hurricane damage potential scale) were observed in the Atlantic basin, having an annual frequency of 0–7 events per year, being more active prior to the mid 1960's than thereafter (hence a possible two-state division: more active versus less active), and being preferentially lower during El Niño years as compared to non-El Niño years. Because decadal averages of the frequency of intense hurricanes closely resemble those of average temperature anomalies for northern hemispheric and global standards and of the average temperature at the Armagh Observatory (Northern Ireland), a proxy for climatic change, it is inferred that the long-term trends of the annual frequency of intense hurricanes and temperature may be statistically related. Indeed, on the basis of 4- and 10-yr moving averages, one finds that there exists strong linear associations between the annual frequency of intense hurricanes in the Atlantic basin and temperature (especially, when temperature slightly leads). Because the long-term leading trends of temperature are now decidedly upward, beginning about mid 1980's, it is inferred that the long-term consequential trends of the annual frequency of intense hurricanes should now also be upward, having begun near 1990, suggesting that a return to the more active state probably has already occurred. However, because of the anomalous El Niño activity of the early to mid 1990's, the switch from the less active to the more active state essentially went unnoticed (a marked increase in the number of intense hurricanes was not observed until the 1995 and 1996 hurricane seasons, following the end of the anomalous El Niño activity.) Presuming that a return to the more active state has, indeed, occurred, one expects the number of seasonal intense hurricanes during the present epoch (continuing through about 2012) to usually be higher than average (i.e., ≥2), except during El Niño-related seasons when the number usually will be less than average.

TP—1998–209005 December 1998

Statistical Aspects of ENSO Events (1950–1997) and the El Niño-Atlantic Intense Hurricane Activity Relationship. Robert M. Wilson. Space Sciences Laboratory. 19990018028N

On the basis of Kevin Trenberth's quantitative definition for marking the occurrence of an El Niño (or La Niña), one can precisely identify by month and year the starts and ends of some 15 El Niño and 10 La Niña events during the interval of 1950–1997, an interval corresponding to the most reliable for cataloguing intense hurricane activity in the Atlantic basin (i.e., those of category 3–5 on the Saffir-Simpson hurricane scale). The main purpose of this investigation is primarily two-fold: First, the statistical aspects of these identified extremes and the intervening periods between them (called "interludes") are examined and, second, the statistics of the seasonal frequency of intense hurricanes in comparison to the extremes and interludes are determined.

This study clearly demonstrates that of the last 48 hurricane seasons, 20 (42 percent) can be described as being "El Niño-related" (i.e., an El Niño was in progress during all, or part, of the year hurricane season—June–November), 13 (27 percent) as "La Niña-related" (i.e., a La Niña was in progress during all, or part, of the yearly hurricane season), and 15 (31 percent) as "interlude-related" (i.e., neither an El Niño nor a La Niña was in progress during any portion of the yearly hurricane season.) Combining the latter two subgroups into a single grouping called "non-El Niño-related" seasons, one finds that they have had a mean frequency of intense hurricanes measuring 2.8 events per season, while the El Niño-related seasons have had a mean frequency of intense hurricanes measuring 1.3 events per season, where the observed difference in the means is inferred to be statistically important at the 99.8-percent level of confidence. Therefore, as previously shown by William Gray and colleagues more than a decade ago using a different data set, there undeniably exists an El Niño-Atlantic hurricane activity relationship, one which also extends to the class of intense hurricanes. During the interval of 1950–1997, fewer intense hurricanes occurred during El Niño-related seasons (always ≤3 and usually ≤2, this latter value having been true for 18 of the 20 El Niño-related seasons), while more usually occurred during non-El Niño-related seasons (typically ≥2, having been true for 22 of the 28 non-El Niño-related seasons). Implications for the 1998 and 1999 hurricane seasons are discussed.

TP—1999–209038 January 1999

Quasi-Static Probabilistic Structural Analyses Process and Criteria. B. Goldberg and V. Verderaime. Structures and Dynamics Laboratory. 19990025665N

Current deterministic structural methods are easily applied to substructures and components, and analysts have built great design insights and confidence in them over the years. However, deterministic methods cannot support systems risk analyses, and it was recently reported that deterministic treatment of statistical data is inconsistent with error propagation laws that can result in unevenly conservative structural predictions. Assuming normal distributions and using statistical data formats throughout prevailing stress deterministic processes lead to a safety factor in statistical format, which integrated into the safety index, provides a safety factor and first order reliability relationship. The embedded safety factor in the safety index expression allows a historically based risk to be determined and verified over a variety of quasi-static metallic substructures consistent with the traditional safety factor methods and NASA Std. 5001 criteria.

TP—1999–209260 June 1999

Material Selection Guidelines to Limit Atomic Oxygen Effects on Spacecraft Surfaces. D. Dooling* and M.M. Finckenor. *D^2 Associates and Space Environments and Effects (SEE) Program. 19990064119N

Material Selection Guidelines to Limit Atomic Oxygen Effects on Spacecraft Surfaces provides guidelines in selecting materials for satellites and space platforms, designed to operate within the Low-Earth orbit environment, which limit the effects of atomic oxygen interactions with spacecraft surfaces.

This document should be treated as an introduction rather than a comprehensive guide since analytical and flight technologies continue to evolve, flight experiments are conducted as primary or piggyback opportunities arise, and our understanding of materials interactions and protection methods grows. The reader is urged to consult recent literature and current web sites containing information about research and flight results.

TP—1999–209263 April 1999

Multilayer Insulation Material Guidelines. M.M. Finckenor and D. Dooling.* Space Environments and Effects (SEE) Program and *D^2 Associates. 19990047691N

Multilayer Insulation Material Guidelines provides data on multilayer insulation materials used by previous spacecraft such as Spacelab and the Long-Duration Exposure Facility and outlines other concerns. The data presented in the document are presented for information only. They can be used as guidelines for multilayer insulation design for future spacecraft provided the thermal requirements of each new design and the environmental effects on these materials are taken into account.

TP—1999–209264 June 1999

Contamination Effects on EUV Optics. J. Tveekrem. Goddard Space Flight Center. Space Environments and Effects (SEE) Program. 19990064368N

During ground-based assembly and upon exposure to the space environment, optical surfaces accumulate both particles and molecular condensables, inevitably resulting in degradation of optical instrument performance.

Currently, this performance degradation (and the resulting end-of-life instrument performance) cannot be predicted with sufficient accuracy using existing software tools. Optical design codes exist to calculate instrument performance, but these codes generally assume uncontaminated optical surfaces. Contamination models exist which predict approximate end-of-life contamination levels, but the optical effects of these contamination levels can not be quantified without detailed information about the optical constants and scattering properties of the contaminant. The problem is particularly pronounced in the extreme ultraviolet (EUV, 300–1,200 Å) and far (FUV, 1,200–2,000 Å) regimes due to a lack of data and a lack of knowledge of the detailed physical and chemical processes involved. Yet it is in precisely these wavelength regimes that accurate predictions are most important, because EUV/FUV instruments are extremely sensitive to contamination.

TP—1999–209267 May 1999

Design and Test of Low-Profile Composite Aerospace Tank Dome (MSFC Center Director's Discretionary Fund Final Report, Project No. 96–28). R. Ahmed. Structures and Dynamics Laboratory. 19990046771N

This report summarizes the design, analysis, manufacture, and test of a subscale, low-profile composite aerospace dome under internal pressure. A low-profile dome has a radius-to-height ratio greater than the square root of two. This effort demonstrated that a low-profile composite dome with a radius-to-height ratio of three was a feasible design and could adequately withstand the varying stress states resulting from internal pressurization. Test data for strain and displacement versus pressure are provided to validate the design.

TP—1999–209373 July 1999

Spacecraft Environments Interactions: Space Radiation and Its Effects on Electronic Systems. J.W. Howard, Jr.* and D.M. Hardage. *Computer Sciences Corporation and Systems Analysis and Integration Laboratory. 19990100675N

The natural space environment is characterized by complex and subtle phenomena hostile to spacecraft. Effects of these phenomena impact spacecraft design, development, and operation. Space systems become increasingly susceptible to the space environment as use of composite materials and smaller, faster electronics increases. This trend makes an understanding of space radiation and its effects on electronic systems essential to accomplish overall mission objectives, especially in the current climate of smaller/better/cheaper faster.

This primer outlines the radiation environments encountered in space, discusses regions and types of radiation, applies the information to effects that these environments have on electronic systems, addresses design guidelines and system reliability, and stresses the importance of early involvement of radiation specialists in mission planning, system design, and design review (part-by-part verification).

TP—1999–209576 September 1999

The Geophysical Fluid Flow Cell Experiment. J.E. Hart,* D. Ohlsen,* S. Kittelman,* N. Borhani,* F. Leslie, and T. Miller. *University of Colorado and Microgravity Sciences and Applications Department. 19990111738N

The Geophysical Fluid Flow Cell (GFFC) experiment performed visualizations of thermal convection in a rotating differentially heated spherical shell of fluid. In these experiments dielectric polarization forces are used to generate a radially directed buoyancy force. This enables the laboratory simulation of a number of geophysically and astrophysically important situations in which sphericity and rotation both impose strong constraints on global scale fluid motions. During USML–2 a large set of experiments with spherically symmetric heating were carried out. These enabled the determination of critical points for the transition to various forms of nonaxisymmetric convection, and, for highly turbulent flows, the transition latitudes separating the different modes of motion. This paper presents a first analysis of these experiments as well as data on the general performance of the instrument during the USML–2 flight.

CP—1998–207891 November 1998
Third United States Microgravity Payload: One Year Report. P.A. Curreri, D. McCauley,* and C. Walker,** Compilers. *University of Alabama in Huntsville and **Universities Space Research Association. 19990020826N

This document reports the one year science results for the Third United States Microgravity Payload (USMP–3). The USMP–3 major experiments were on a support structure in the Space Shuttle's payload bay and operated almost completely by the Principal Investigators through telescience. The mission included a Glovebox where the crew performed additional experiments for the investigators. Together about seven major scientific experiments were performed, advancing the state of knowledge in fields such as low temperature physics, solidification, and combustion. The results demonstrate the range of quality science that can be conducted utilizing orbital laboratories in microgravity and provide a look forward to a highly productive space station era.

CP—1998–208868 November 1998
Microgravity Science Laboratory (MSL–1) Final Report. M.B. Robinson, Compiler.
19990019800N

This document reports the results and analyses presented at the Microgravity Science Laboratory (MSL–1) One Year Science Review meeting held at Marshall Space Flight Center August 25–26, 1998. The MSL–1 payload first flew on the *Space Shuttle Columbia* (STS–83) April 4–8, 1997. Due to a fuel cell problem, the mission was cut short, and the payload flew again on *Columbia* (STS–94) July 1–17, 1997. The MSL–1 investigations were performed in a pressurized Spacelab module and the Shuttle middeck. Twenty-nine experiments were performed and represented disciplines such as fluid physics, combustion, materials science, biotechnology, and plant growth. Four accelerometers were used to record and characterize the microgravity environment. The results demonstrate the range of quality science that can be conducted utilizing orbital laboratories in microgravity.

CP—1998–209006 December 1998
New Space Industries for the Next Millennium. D.V. Smitherman, Jr., Compiler. Program Development Directorate. 19990021561N

New Space Industries for the Next Millennium is a final report of the findings from the New Space Industries Workshop held in Washington, DC, in February 1998. The primary purpose of this workshop was to identify what must be done to develop new markets, and to generate plans, milestones, and new organizational relationships designed to facilitate the goal of space development. This document provides a summary report on the results of that workshop and is not intended as a statement of NASA or government policy.

Previous studies had shown great potential for the development of new markets in space (e.g., travel and entertainment, space solar power, satellite and space transfer services, research and development in space, space manufacturing, and space resources), and a great need for coordination and formation of infrastructures (e.g., space transportation, space business parks, and space utilities), to facilitate the growth of new space businesses. The New Space Industries Workshop brought together government, academia, and industry participants from several previous studies and other professionals interested in the development of space for commercial purposes. Their participation provided input into the role of government and industry in space development as well as the technology needs that will enable space development.

The opening of the frontier of space, not just to government missions but to private individuals and commercial business, is a challenge of overarching importance. It is our hope that the workshop and this final report continue in earnest the process of identifying and overcoming the barriers to large-scale public access and development of space in the early years of the next century.

CP—1999–209092 February 1999
NASA Microgravity Materials Science Conference. D.C. Gillies and D.E. McCauley,* Compilers. *University of Alabama in Huntsville.
19990040241N

The Microgravity Materials Science Conference was held July 14–16, 1998 at the Von Braun Center in Huntsville, AL. It was organized by the Microgravity Materials Science Discipline Working Group, sponsored by the Microgravity Research Division at NASA Headquarters, and hosted by the NASA Marshall Space Flight Center and the Alliance for Microgravity Materials Science and Applications. It was the third NASA conference of this type in the microgravity materials science discipline. The microgravity science program sponsored approximately 125 investigations and 100 principal investigators in FY98, almost all of whom made oral or poster presentations at this conference. The

conference's purpose was to inform the materials science community of research opportunities in reduced gravity in preparation for a NASA Research Announcement scheduled for release in late 1998 by the Microgravity Research Division at NASA Headquarters. The conference was aimed at materials science researchers from academia, industry, and government. A tour of the Marshall Space Flight Center microgravity research facilities was held on July 16, 1998. This volume is comprised of the research reports submitted by the principal investigators after the conference.

CP—1999–209144 February 1999
The 1998 NASA Aerospace Battery Workshop. J.C. Brewer, Compiler. 19990032324N

This document contains the proceedings of the 31st annual NASA Aerospace Battery Workshop, hosted by the Marshall Space Flight Center on October 27–29, 1998. The workshop was attended by scientists and engineers from various agencies of the U.S. Government, aerospace contractors, and battery manufacturers, as well as international participation in like kind from a number of countries around the world.

The subjects covered included nickel-hydrogen, silver-hydrogen, nickel-metal hydride, and lithium-based technologies, as well as results from destructive physical analyses on various cell chemistries.

CP—1999–209146/VOL. 2 February 1999
General Public Space Travel and Tourism—Volume 2 Workshop Proceedings. D. O'Neil, Compiler, I. Bekey,* J. Mankins,* W. Piland,** T. Rogers,*** and E. Stallmer,*** Editors. *NASA Headquarters, **Langley Research Center, and ***Space Transportation Association. 19990041888N

The Space Transportation Association and NASA conducted a General Public Space Travel study between 1996 and 1998. During the study, a workshop was held at Georgetown University. Participants included representatives from the travel, aerospace, and construction industries. This report is the proceedings from that workshop. Sections include infrastructure needs, travel packages, policy related issues, and potential near-term activities.

CP—1999–209258 April 1999
Third Aerospace Environmental Technology Conference. A.F. Whitaker, D.R. Cross, S.V. Caruso, M. Clark-Ingram, Editors. Materials and Processes Laboratory. 19990075847N

The elimination of CFC's, Halons, TCA, other ozone depleting chemicals, and specific hazardous materials is well underway. The phaseout of these chemicals has mandated changes and new developments in aerospace materials and processes. We are beyond discovery and initiation of these new developments and are now in the implementation phase. This conference provided a forum for materials and processes engineers, scientists, and managers to describe, review, and critically assess the evolving replacement and clean propulsion technologies from the standpoint of their significance, application, impact on aerospace systems, and utilization by the research and development community. The use of these new technologies, their selection and qualification, their implementation, and the needs and plans for further developments were presented.

CP—1999–209261 June 1999
11th International Conference on Atmospheric Electricity. H.J. Christian, Compiler. Global Hydrology Research Office. 19990108601N

This document contains the proceedings from the 11th International Conference on Atmospheric Electricity (ICAE 99), held June 7–11, 1999. This conference was attended by scientists and researchers from around the world.

The subjects covered included natural and artificially initiated lightning, lightning in the middle and upper atmosphere (sprites and jets), lightning protection and safety, lightning detection techniques (ground, airborne, and space-based), storm physics, electric fields near and within thunderstorms, storm electrification, atmospheric ions and chemistry, shumann resonances, satellite observations of lightning, global electrical processes, fair weather electricity, and instrumentation.

CP—1999–209628 September 1999
Fourth United States Microgravity Payload: One Year Report. E.C. Ethridge, P.A. Curreri, and D.E. McCauley,* Compilers. *University of Alabama in Huntsville.

This document reports the one year science results for the Fourth United States Microgravity Payload (USMP–4). The USMP–4 major experiments were on a support structure in the Space Shuttle's payload bay and operated almost completely by the Principal Investigators through telescience. The mission included a Glovebox where the crew performed additional experiments for the investigators. Together about eight major scientific experiments were performed, advancing the state of

knowledge in fields such as low temperature physics, solidification, and combustion. The results demonstrate the range of quality science that can be conducted utilizing orbital laboratories in microgravity and provide a look forward to a highly productive Space Station era.

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19990040178N

CR—1999–208189 February 1998
Study Methods to Standardize Thermography NDE—Final Report. NAS8–38609, D.O. #174. University of Alabama in Huntsville.
19990040422N

CR—1999–208190 August 1998
Injector Mixing Efficiency Experiments—Final Report. NAS8–38609, D.O. #159. University of Alabama in Huntsville.
19990040421N

CR—1999–208191 September 1998
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19990042214N

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19990041442N

CR—1998–208859 October 1998
A Compendium of Wind Statistics and Models for the NASA Space Shuttle and Other Aerospace Vehicle Programs. NAS8–60000. Computer Sciences Corporation.
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A Survey of Radiation Measurements Made Aboard Russian Spacecraft in Low-Earth Orbit. NAS8–40294. Eril Research, Inc.
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CR—1999–209426 July 1999
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Shuttle Mission STS–50: Orbital Processing of High-Quality CdTe Compound Semiconductors Experiment—Final Flight Sample Characterization Report. NAS8–38147. Northrop Grumman Corporation.
19990064432N

CR—1999–209568 December 1998
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19990092480N

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19990116348N

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Specification, Measurement, and Control of Electrical Switching Transients. EMC Compliance.

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PRICE, J. EP62
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NDAP, J.-O. Fisk University
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FETH, S. ES75
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ZHOU, N. CFD Research Corp.
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BACHMANN, K.J. North Carolina State
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SCHMIDT, G.R. TD40
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HURST, C.M. Purdue University
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BOECK, W.L. Niagara University
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KARR, L.J. ES76
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SCHWEIZER, M. SD47
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JEDLOVEC, G. SD60
A Regional-Scale Assessment of Satellite Derived Precipitable Water Vapor Across the Amazon Basin. For presentation at 10th Conference of Satellite Meteorology & Oceanography, Long Beach, CA, January 10–14, 2000.

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